PDL5 PDL/IL/BR Multimeter

User Manual

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1

COMPLIANCE

FDA-CDRH Compliance

Under the US Food and Drug Administration (FDA) Center for Devices and Radiological Health (CDRH), the unit complies with the Code of Federal Regulations (CFR), Title 21, Subchapter J, which pertains to laser safety and labeling. See the link below for more information.

- *http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?CFRPartFrom=1000&CFRPartTo=1050*

CSA / IEC Compliance

The unit complies with certain standards of the Canadian Standards Association (CSA) and the International Electrotechnical Commission (IEC).

The unit falls in the Installation Category (Overvoltage Category) II under IEC 664. IEC 664 relates to impulse voltage levels and insulation coordination. The particular category is defined as: local level, appliances, portable equipment, etc, with smaller transient overvoltages than Installation Category (Overvoltage Category) III.

The unit falls in the Pollution Degree 2 category under IEC 1010-1 and CAN/CSA-C22.2 No. 1010.1. The IEC standard on Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use relates to insulation coordination. The CSA standard is on Safety Requirements for Electrical Equipment for Measurement Control, and Laboratory Use, Part I: General Requirements. The Pollution Degree 2 category is defined as follows: "Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected."

CE Compliance

Electronic test equipment is subject to the EMC Directive in the European Union. The EN61326 standard prescribes both emission and immunity requirements for laboratory, measurement, and control equipment. This unit has undergone extensive testing according to the European Union Directive and Standards.

2

GENERAL INFORMATION

PDL5 PDL/IL/BR Multimeter Overview

The PDL5 PDL/IL/BR Meter is a portable, direct-display instrument that measures polarization dependent loss (PDL), insertion loss (IL), backreflection (BR) and power of single-mode fiberoptic devices (i.e. connectors, components, and systems).

The PDL5 multimeter may be ordered with up to four internal laser sources for operation at 1310, 1490, 1550, 1625 and/or 1650 nm. A variety of detector adapters are available to enable the measurement of power (i.e. IL) from different connector types.

Figure 1: PDL5 PDL/IL/BR Multimeter

An important feature of the PDL5 multimeter is the FC/APC ultra-low backreflection connector at its output port. To test different connector types, the user needs only to change the hybrid launch jumpers, of which one side has a FC/APC connector, and the other connector type to be tested. The connector's end face condition is very important as it directly affects the performance of the meter.

The PDL5 multimeter is supplied with two hybrid jumpers. The first one, called measurement jumper, is to be used for every measurement and the second one, called calibrated jumper, is to be used for calibration verification only.

To ensure measurement quality, only calibration jumpers provided by JGR Optics should be used. However, additional measurement jumpers may be supplied by the customer, third parties or JGR Optics.

In addition to manual front panel operation, the PDL5 multimetermeter may be operated over the RS-232 serial interface and IEEE 488 GPIB parallel interface. Please refer to the “REMOTE CONTROL COMMANDS” section on page 45 for more information.

Measurements

Polarization Dependent Loss Measurement

The PDL5 Multimeter can be configure to use the 4-state or 6-state Mueller matrix method to measure PDL of the DUT.

In the 4-state matrix calculation method, transmission measurements are performed at four orthogonal states of polarization, normally 0, 45 and 90 degree linear states are used along with a right-hand circular state.

One method to determine the PDL of a component is to calculate the insertion loss of all the possible polarization states to a given resolution and take the difference between the minimum (ILmin) and maximum (ILmax) insertion losses as the PDL. The PDL5 multimeter calculates the PDL and average loss (ILavg) analytically, using the values in the first row of the Mueller matrix.

Although the PDL and average loss are displayed in decibels (dB), the average loss is the average transmission converted to decibels. Thus, the average loss of an ideal polarizer is 3 dB = [-10 log (0.5)].

Generally, the minimum and maximum insertion losses can be calculated using the following formulas:

ILmin = ILavg + 10 log [(1+10(-PDL/10))/2] dB and ILmax = ILmin + PDL dB

However, for small PDLs the following formulas are used:

ILmin = ILavg - PDL/2 dB and ILmax = ILavg + PDL/2 dB.

When increased accuracy on PDL measurement is required, it is possible to select the 6-state Mueller matrix method. Measurement time will be longer however as the internal polarization controller has to generate two additional polarization states: -45 degree linear state and left-hand circular state.

Backreflection Measurement

The PDL5 is an easy to use instrument that can measure both insertion loss and backreflection parameters. In Backreflection mode, the PDL5 measures the difference between the output power (Pout) and the reflected power (Prefl) and automatically calculates and displays the backreflection.

The internal switch and coupler of the PDL5 multimeter enable it to automatically reference out the variations of the internal light source, the signal offset with no light (dark current), and the total signal level from internal and external backreflection (BRtot).

The backreflection in dB from a device under test (BR_{DUT}) is calculated using the following equation, where BR0 is the stored value of the total backreflection (in dB) of the device under test (DUT):

$$BR_{DUT} = 10 \bullet \log\left(10^{BR_{tot}/10} - 10^{BR_0/10} \right)$$

The PDL5 meter displays the value of BR_{DUT}.

During power up, the meter will measure the dark current and the reference power. Approximately every 90 seconds, the meter will automatically update the reference power measurement, a process that only takes a fraction of a second and does not cause any significant delays. In normal operation, the PDL5 multimeter can take approximately 3 backreflection measurements per second.

Loss and Power Measurement

The PDL5 multimeter is equipped with a front-panel InGaAs or Ge detector for relative power (loss) and absolute power measurements. The meter is capable of storing the dark signal from the detector so that high accuracy measurements (as low as -80dBm for an InGaAs detector and -60 dBm for Ge detector) are possible.

When making power measurements, the PDL5 multimeter will automatically correct for dark current if the value has been stored. The power displayed (P) in dBm is calculated from the total current measured when the light source to be measured is illuminating the detector (Itot) and the value of the leakage or dark current (Id) measured, using the following equation:

$$P = 10 \bullet \log(I_{tot} - I_d) + CAL$$

Where “CAL” is the factory calibration value and is dependent on the wavelength.

Output Port

The output ports of the PDL5 multimeter are equipped with an ultra-low backreflection APC connector. To prevent damage to the output port connectors, a measurement jumper (also called “launch cable”) must be used for all measurements, even for measuring a component with an APC connector.

Extreme care must be taken to avoid damaging the connector when plugging and unplugging the launch cable. Connection must be kept clean and should be inspected before every mating (this means both connectors, the FC/APC on the launch cable and the FC/APC connector on the PDL5 multimeter). Please refer to the Cleaning Connectors section on page 36 for more information.

Hybrid Jumper

The PDL5 multimeter is supplied with a hybrid measurement jumper and a hybrid calibrated jumper. The measurement jumper has an APC connector at the input end. The other end on the standard measurement jumper is UPC but, by changing measurement jumpers, this end is user-selected to be compatible with the input connector of the DUT; for example SC/UPC or APC or LC/APC or UPC. The calibrated jumper has an APC connector at the input end and a UPC connector at the output end.

Remember to use the measurement jumper for measurement purposes only and to use the calibrated jumper for calibration verification purposes only. The calibrated jumper has a label attached to it identifying it as such.

Coherence Length

Reflected light from multiple reflections can change the backreflection measured by the PDL5 multimeter. This variation typically shows up as noise or drift in the signal. The internal light source is designed to have low coherence length (typically less than 10 cm). Thus, interference effects are typically seen only between very closely spaced components such as non-contacting connectors.

Key Features

- Ultra stable and accurate PDL, IL ave., Loss & Backreflection measurements
- Up to 4 built-in light sources at 1310, 1490, 1550 and/or 1625 nm
- Up to 2 output channels or 4 detectors
- 4 or 6 state Mueller Matrix methods
- Resolution down to 0.001dB
- ≈ 1 second PDL measurements

Applications

- Optical component testing
- Incoming inspection
- Quality assurance (QA) testing

Accessories

- AC power cord
- FC/APC-FC/UPC hybrid test jumper
- 1 FC/APC-FC/UPC hybrid calibrated jumper
- FC-type detector adapter
- Detector cap
- MW3 Mandrel Wrap
- User Manual
- NIST traceable Calibation Certificate

Optional Accessories

- Variety of detector adapters
- Remote head
- Measurement jumpers with various user-selected connectors

3

SAFETY INFORMATION

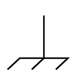
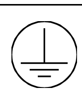
To avoid situations that could result in serious injuries or death, always observe the following precautions.

The safety instructions must be observed whenever the unit is operated, serviced, or repaired. Failure to comply with any of these instructions or with any precaution or warning contained in the User Manual is in direct violation of the standards of design, manufacturing, and intended use of the unit. JGR Optics assumes no liability for the customer's failure to comply with any of these safety requirements.

Safety Markings on the Unit

The following symbols and messages can be marked on the unit (see Table 1 below). Observe all safety instructions that are associated with a symbol.

Table 1: Safety Symbols

	Laser radiation may be present. Refer to the User Manual for instructions on handling and operating the unit safely. Avoid looking into any ports near which this symbol appears.
	Frame or chassis terminal for electrical grounding within the unit.
	Protective conductor terminal for electrical grounding to the earth.
WARNING	Procedure can result in serious injury or loss of life if not carried out in proper compliance with all safety instructions. Ensure that all conditions necessary for safe handling and operation are met before proceeding.
CAUTION	Procedure can result in serious damage to or destruction of the unit if not carried out in compliance with all instructions for proper use. Ensure that all conditions necessary for safe handling and operation are met before proceeding.

Classification

The PDL5 PDL/IL/BR Multimeter consists of an exposed metal chassis that is connected directly to earth via a power cord and, therefore, is classified as a Class 1 instrument.

Laser Specifications

The laser (or lasers) contained in the PDL5 multimeter is (are) Class 1 laser(s) as specified under the laser classification of the US Food and Drug Administration (FDA) Center for Devices and Radiological Health (CDRH). Laser specifications are provided in Table 2 below.

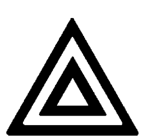
CLASS 1
LASER PRODUCT

Table 2: Specifications

Parameter	***Single-mode (SM)***
Wavelength	1310, 1490, 1550, or 1625 ± 10 nm
Class	1
Fiber Type	SMF-28e (9/125)
Maximum Accessible Emission Level	-15 dBm
Maximum Output Power	1 mW, Class 1
Effective Numerical Aperture	0.20

Important Safety Information

Laser Hazards

	Warning Never look into the end of an optical cable connected to an optical output device that is operating. Laser radiation is invisible, and direct exposure can severely injure the human eye.

Electrical Shock Hazards

Warning

- Some of the circuits are powered whenever the unit is connected to the AC power source (line power). To ensure that all circuits are powered off, disconnect the power cord from either the power inlet on the unit's rear panel or from the AC line-power source (receptacle). The power cord must always be accessible from one of these points. If the unit is installed in a cabinet, the operator must be able to disconnect the unit from the line power by the system's line-power switch.
- Use only the type of power cord supplied with the unit. If you need to replace a lost or damaged cord, make sure to replace with a power cord of the same type.
- Connect the power cord only to a power outlet equipped with a protective earth contact. Never connect to an extension cord or any receptacle that is not equipped with this feature.
- If using a voltage-reducing autotransformer to power the unit, ensure that the common terminal connects to the earthed pole of the power source.
- Do not interrupt the protective earth grounding. Such action can lead to a potential shock hazard that can result in serious personal injury. Do not operate the unit if an interruption to the protective grounding is suspected.
- Do not operate the unit when its cover or panels have been removed.
- To prevent potential fire or shock hazard, do not expose the unit to any source of excessive moisture.
- Do not use the unit outdoor.
- Operating the unit in the presence of flammable gases or fumes is extremely hazardous.
- If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Only technicians authorized by JGR Optics should carry out the repairs. In addition to voiding the warranty, opening the unit (even when unplugged) can expose you to potential shock hazards.

	• Some of the unit's capacitors can be charged even when the unit is not connected to the power source. • Do not perform any operating or maintenance procedure that is not described in the User Manual.

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GETTING STARTED

⚠	**Caution** To avoid injury or death, always observe the precautions listed in "SAFETY INFORMATION" section on page 8.

This manual contains complete operating instructions for safe and effective operation of the PDL5 PDL/IL/BR Multimeter. It is recommended that users of the PDL5 familiarize themselves with contents of this manual before using the instrument.

The inspection report and a description of any customer-requested information may be found in the calibration document envelope included with the instrument.

Initial Inspection

⚠	**Warning** To avoid electrical shock, do not initialize or operate the unit if it bears any sign of damage. Ensure that the unit and any devices or cords connected to it are properly grounded.

☑ Inspect the package and contents for signs of damage.

☑ Ensure all contents are included:

- PDL5 PDL/IL/BR Multimeter
- 1 AC power cord
- 1 FC/APC-FC/UPC hybrid test jumper
- 1 FC/APC-FC/UPC hybrid calibrated jumper
- 1 FC-type detector adapter
- 1 Detector cap
- MW3 Mandrel Wrap

- User Manual
- NIST traceable Calibration Certificate

☑ Read the User Manual thoroughly, and become familiar with all safety symbols and instructions to ensure that the unit is operated and maintained safely.

☑ Ensure the unit is operational:

- Connect the unit to a power source using the power cord provided
- Set the power switch to ON to initialize the PDL5 meter, and observe the power-up sequence:
- Model number and firmware version of the meter are displayed
- Internal measurements of Pin and Pdark are made
- The message “Initializing” is displayed as the light source stabilizes
- The backreflection value (BR) of the front panel connector is measured and displayed
- Set the power switch to OFF and disconnect the meter.

☑ Keep the packaging.

☑ Immediately notify JGR Optics and, if necessary, the carrier if the content of the shipment is incomplete, if the unit or any of its components are damaged or defective, or if the unit does not pass the initial inspection.

Operational Requirements

In order for the unit to meet the warranted specifications, the operating environment must meet the following conditions for altitude, temperature, humidity, and voltage.

Table 3: Environmental Requirements

Parameter	***Specification***
Altitude	Up to 2000 m
Temperature	Range of 0 to 40 °C
Humidity	Up to 95% humidity (0 to 40 °C)
Voltage	Main supply voltage fluctuations must not exceed ±10% of the nominal voltage

NOTE: The PDL5 multimeter may be equipped with up to four internal laser sources. These are thermoelectrically cooled for added stability and are modulated at 10 KHz. Sudden changes in ambient temperature can cause one or several of the sources to become unstable. If this occurs, the meter automatically switches to a measuring mode in which Pin and Pdark are measured more frequently than every minute and the message "Source Unstable" is displayed. The light sources power is monitored, and the meter returns to the standard measurement mode when the sources have stabilized.

Product Overview

Front Panel and Key Description

A front view of the PDL5 multimeter is shown on Figure 2 and a detailed description of keys and LEDs is provided in Table 5 on next page.

Note that the meter front panel will vary with model ordered.

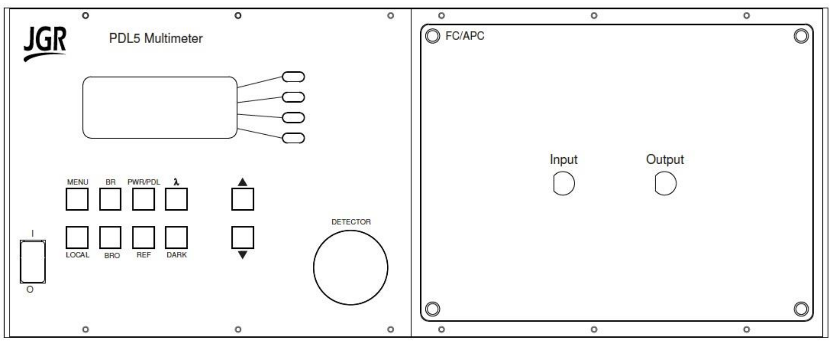

Figure 2: Front of the Meter

Rear Panel

The back of the meter is shown in Figure 3 and the rear-panel features are described in Table 4.

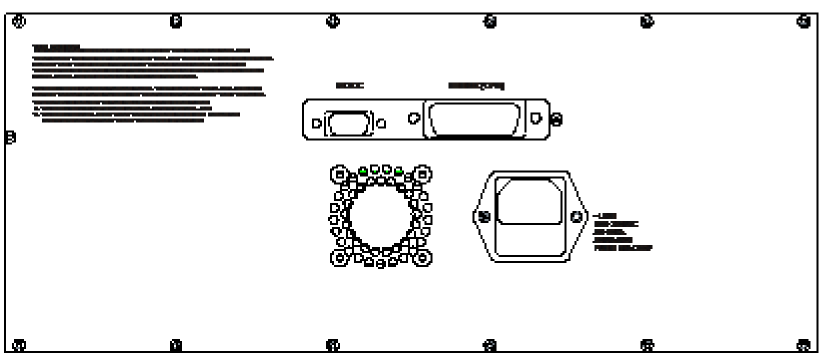

Figure 3: Back of the Meter

Table 4: Rear Panel Components

Component	***Function***
RS-232C	RS-232C serial interface port
IEEE 488 (GPIB)	GPIB (IEEE 488.1) interface port
~LINE	Power Input (also contains the user-replaceable fuse)

Table 5: Operating Keys and Status LEDs

Key/LED	***Description***
I/O	ON / OFF Power switch.
MENU	Used to turn the Menu mode on and off. When deeper menu levels are selected, press the MENU key to step back one level at a time.
λ	Selects one of the two to four laser sources (depending on model ordered). Hold the λ key until "LD modulation OFF for scope" message is displayed to put PDL5 lasers in CW mode.
▲ ▼	Selects the output channel and adjusts the LCD Display values.
BR	Press once to set the meter to backreflection measurement mode.
BR_0	Used to measure and store the backreflection value as BR_0. The key LED will light up to indicate that the function is on. To restore the factory-set BR_0 value, press the BR_0 key again. The key LED will turn off.
PWR/PDL	Used to switch to IL and PDL or Optical Power Measurement modes. Press once to select IL and PDL measurement mode, press a second time to select absolute power measurement.
REF	Sets the reference power for relative power measurements and adjusts the BR offset simultaneously. If held for 2 seconds, the REF button sets reference power for relative power measurements and BR offset for all available wavelengths.
DARK	Used to measure and store the user ID value used in dark measurements. Key LED will light up when selected.
LOCAL	Brings the meter back to local mode when operating remotely (with GPIB or RS-232/USB).
Soft Keys ⬬	Used to toggle the MENU items displayed or special functions that are activated.

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OPERATION

Before the PDL5 multimeter can be used to make a measurement, the user must setup the meter and connect and reference a “measurement jumper” to the front panel connector.

Powering Up the Meter

To power up the meter:

1. Connect the meter to an AC power source using the power cord provided. If the meter has been running, ensure that the meter is powered off and restarted.
2. Set the power switch to I (ON), and wait for the “Initialization” process to finish.
3. Allow a 30 minute warm-up time in order to obtain an accurate reading.

Backreflection Measurements

Backreflection (BR) measurements with the PDL5 require terminating the fiber at two different points. The difference in the backreflection between the two termination points is then calculated and displayed. By choosing the termination points before and after a DUT, the backreflection of the DUT can be measured.

To perform BR measurements, two terminations must be made:

- Before the DUT, for example, on the BR5 meter side (for measuring BR_0)
- After the DUT (for measuring BRtot)

If measuring very low backreflection in single-mode fiber, both termination points need to be made as close as possible to the DUT to minimize the errors associated with Rayleigh backscattering in the fiber. The backreflection of all components and connections between these two points is included in the equation for calculating the backreflection value (BR) of the DUTs.

Set-up for BR Measurements

To prepare the meter for backreflection measurements:

1. Follow the "POWERING UP THE METER" sequence on page 17.
2. Clean the output port on the front of the meter and the FC/APC connector of the measurement jumper (see the "CLEANING THE CONNECTOR ENDS" section on page 35).
3. Connect the FC/APC end of the measurement jumper to the output port on the meter. Make sure to properly align the connector key and screw it firmly but do not over screw. The output connector of the measurement jumper is user-selected and must be compatible with the input connector of the DUT.
4. Attach the appropriate adapter to the detector on the front of the meter.
5. Press the BR key to set the meter to Backreflection mode. BR mode is indicated on the display.
6. Press the ▲ or ▼ key to select the required output port (if multi-port unit is used).
7. Press the λ key to select the required wavelength.
8. Clean and connect the output connector of the measurement jumper to the detector adapter on the front of the meter.
9. Press the REF key; the offset value (equal to twice the measured loss) is briefly displayed. A small dot on the bottom right of the LCD display is displayed to indicate that the meter is using the measured offset value to calculate the backreflection.
10. To have the meter perform the setup for all wavelengths, press and hold the REF key for two seconds.
11. Repeat steps 1 to 10 for the next required output port.
12. Disconnect the output connector from the detector adapter.

Measuring BR_0

1. Press the λ key to select the required wavelength.
2. Terminate the measurement jumper just before the output connector, and hold the termination point steady. Refer to the "TERMINATION TECHNIQUES" section for more information on how to properly perform a termination on page 27.
3. Press the BR_0 key to store the new BR_0 value. The key LED will light up to indicate that the BR_0 value has been stored. If a previous BR_0 measurement has already been stored (i.e. the BR_0 LED is already

ON), the old value must be deleted first by pressing the BR_0 key to turn the BR_0 LED OFF. Pressing the BR_0 button again will store the new value.

Repeat the preceeding steps for all other wavelengths at which the measurements are to be made.

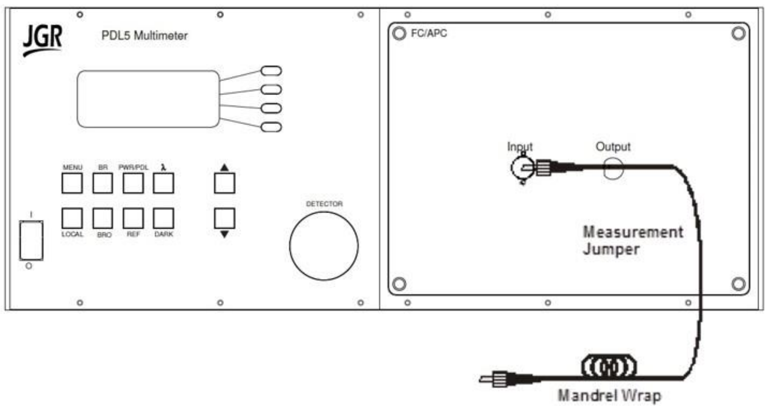

Figure 4: Measuring BR_0 (Mandrel Technique)

Measuring BR (Including Connector)

Once a BR_0 measurement is performed and the value stored, the second termination is made after the DUT in order to obtain BRtot . To measure the backreflection from a DUT, such as a connector, follow the instructions below.

NOTE: Only Single-Mode fiber termination is shown. Please refer to the "TERMINATION TECHNIQUES" section for multimode fiber termination.

1. Clean the output connector of the measurement jumper and the input connector of the DUT, and mate the two. Refer to the "CLEANING CONNECTORS" section for more information on page 36.
2. Press the λ key to select the wavelength at which the measurement is to be made.
3. Terminate the measurement jumper immediately after the DUT (see Figure 5 and Figure 6) and hold the termination point steady.
4. The meter displays the backreflection that is caused by the fiber, all connections, and the DUT that lies between the two termination points (that is the termination point for BR_0 and the current termination point. This area is shown within the dashed line in Figure 7.

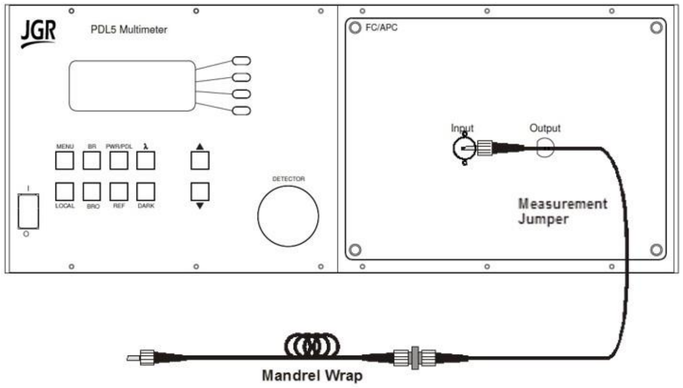

Figure 5: Measuring backreflection of a connector

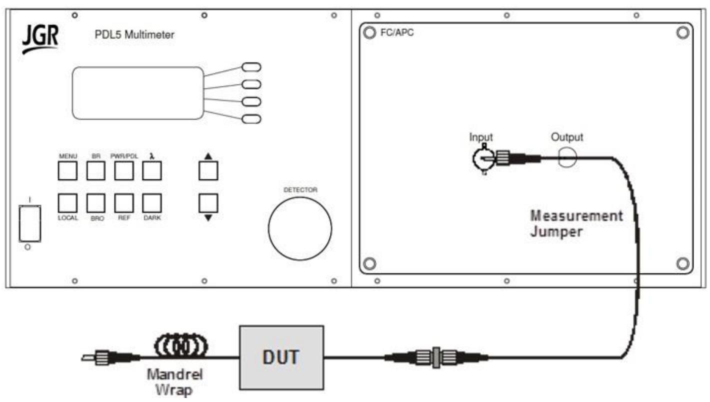

Figure 6: Measuring backreflection of a connectorized DUT

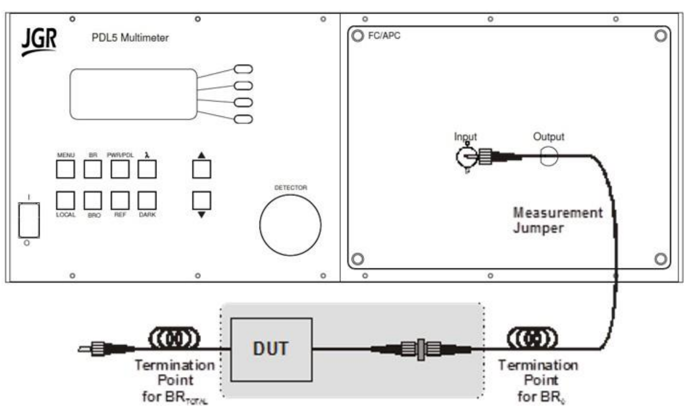

Figure 7: Backreflection measurement area

Measuring BR (Excluding the Connector)

The method described in the "MEASURING BR (Including Connector)" section is used to measure the backreflection if the DUT is a connector, or if the DUT is a connectorized component and the total backreflection from the connector and the DUT is desired.

It is sometimes desirable to know the backreflection of a connectorized DUT, but excluding the connector. If the fiber type is single-mode, this is possible, but a few extra steps must be taken for every measurement to reference out the connector (i.e., the user must do a BR_0 for every DUT).

Refer to the "MEASURING BR (Including Connector)" section and redo the BR_0 measurements for each wavelength, but this time, when terminating between the DUT's connector and the DUT. Note that if a BR_0 value has already been stored, it is required to press the BR_0 button first, to erase it and then press it again to store the new value.

Create a termination point on the pigtail after the DUT. The meter now displays the backreflection of the DUT only.

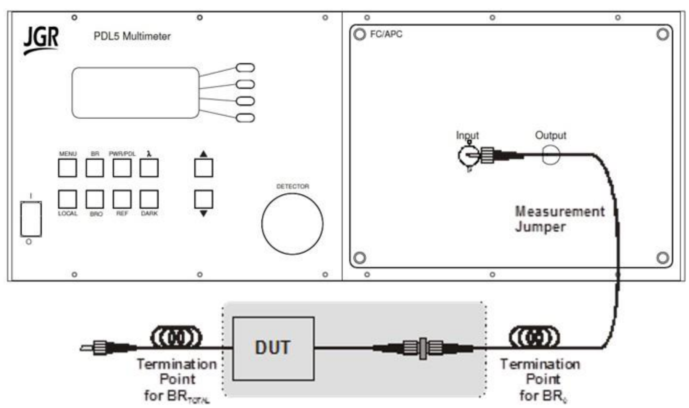

Figure 8: Measuring BR – Excluding Connector

Backreflection Accuracy and Range

The absolute accuracy of backreflection measurements made with the meter is dependent on the level of backreflection to be measured.

The backreflection measurement range is restricted by the BR_0 level. The meter can measure backreflection levels 15 dB below BR_0 to a maximum of -80 dB. For example, if BR_0 is -40 dB, the minimum backreflection of the DUT that can be measured is -55 dB.

An asterisk (*) is displayed near the range limit (last 5 dB of range if using BR_0, below -60 dB otherwise) to indicate that the setup and measurement procedures described in the previous two sections must be followed carefully to ensure accurate results.

The small amount of reflections that BR0 represent can be polarization sensitive, and multiple reflections can cause interference effects that can make the reflections very sensitive to temperature.

NOTE: To ensure accurate backreflection measurements below -65 dB, perform the BR_0 measurement at least once per shift.

The measured backreflection is also affected by losses that can occur between the meter and the DUT. To compensate for these losses, measure the total amount of loss between the output of the measurement hybrid jumper and the input of the DUT (see "LOSS AND POWER MEASUREMENT" section on page 22), double this value and add it to the backreflection value displayed on the meter.

In the following example, the total loss between the meter and the DUT is 2.0 dB, and the displayed backreflection is -29 dB:

BR = -29 dB + (2 x 2.0 dB) = -25 dB

Absolute accuracy specifications are dependent upon the accuracy of the PDL5 meter calibration, so a calibration verification needs to be performed periodically. Refer to the "CALIBRATION" section on page 32 for more information.

Polarization Dependent Loss (PDL), Loss and Power Measurements

Set-Up for PDL, Loss and Power Measurements

To prepare the meter for PDL, Loss and Power measurements:

1. Follow the "POWERING UP THE METER" sequence on page 17.
2. Press the ▲ or ▼ key to select the required output port.
3. Clean the output port on the front of the meter and the FC/APC connector of the measurement jumper (see the "CLEANING THE CONNECTOR ENDS" section on page 35).
4. Connect the FC/APC end of the jumper to the output port on the meter.

NOTE: Ensure that you are using the measurement jumper and not the calibration jumper, which is labeled as such.

5. Attach the appropriate detector adapter to the detector on the front of the meter.
6. Connect the output connector of the measurement jumper to the detector adapter. This end of the measurement jumper is user-selected and must be compatible with the input connector of the DUT.

7. Press the λ key to select the desired wavelength.
8. Press the PWR/PDL key to set the meter in ILa and PDL measurement mode. The internal polarization controller will automatically start once this mode is selected. In this mode, the meter displays "ILa" and "PDL" and the reading for each measurement (i.e. -0.15 dB) is displayed after the label.
9. Press REF key to take both ILa and PDL references. The display reads 0.00 dB for both measurements. The loss and PDL of the measurement jumper are substracted from the DUT loss or power measurement to be made (see Figure 9).
10. Pressing and holding the REF key will take a reference at each wavelength.
11. Press the PWR/PDL key again to set the meter to Absolute Power mode. When in Absolute Power mode, the meter displays "Absolute Power" at the bottom of the screen, in contrast, "Relative Power" is displayed during relative power mode.
12. Press REF key to switch to relative power mode and take a reference. The display reads 0.00 dB. The loss of the measurement jumper is subtracted from the DUT loss or power measurement to be made (see Figure 9).
13. Pressing and holding the REF key will take a reference at each wavelength.
14. Repeat steps 1-10 for the next required output port.

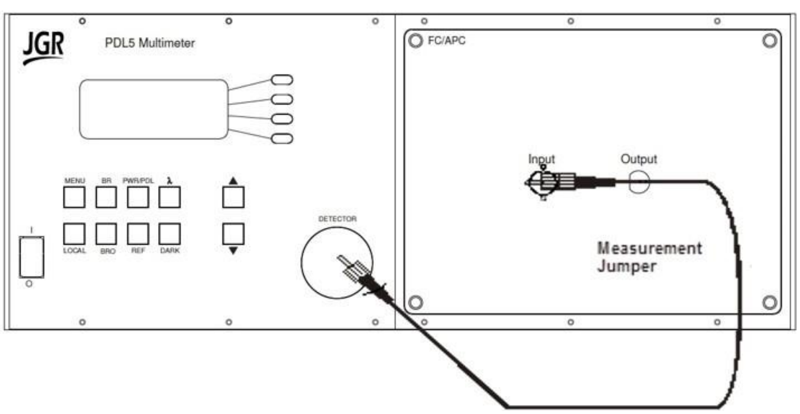

Figure 9: PDL, Loss and Power Measurements

Dark Current Measurement

For loss and power measurements below -50 dBm, it is necessary to perform a dark current measurement (measurement of power with no light).

1. Ensure that the detector is covered, for example, that the detector cap is on or the output connector is connected to the detector. This dark current value will be subtracted from future loss and power measurements.
2. Press the DARK key. The key LED lights up to indicate that the user-stored value of ID (the dark signal from extraneous sources) is used to calculate the DUT loss or power.
4. If the detector is not properly covered, the message "Too Much Light!" is displayed. If the ID value is not stored prior to a measurement, the last value stored is used.

Measuring Absolute Power

In Absolute Power mode, measurements are displayed in dBm.

To perform power measurement of a DUT, make sure to perform the set-up steps in the "SET-UP FOR PDL, LOSS AND POWER MEASUREMENTS" section on page 22 and then, follow these steps:

1. Press the PWR/PDL key twice to set the meter to Power mode.
2. Press the ▲ or ▼ key to select the required output port.
3. Press the λ key to select the wavelength at which the measurement is to be performed.
4. Clean the output connector of the measurement jumper and the input connector of the DUT, and connect the two connectors.
5. Connect the output connector of the DUT to the detector on the front of the meter. The detector must be equipped with the appropriate detector adapter. The PDL5 meter displays the DUT absolute power output (see Figure 10).
6. For measurements at additional wavelengths, repeat the steps 2 to 5 for each wavelength.

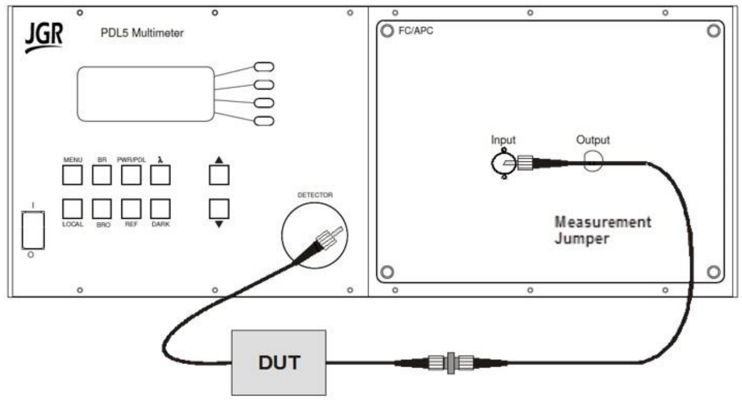

Figure 10: Measuring Absolute Power

Measuring Relative Power

The relative power value displayed by the PDL5 meter is the negative value of the insertion loss, for example -31 dB instead of 31 dB, if the reference was made with the Measurement jumper and the relative power measurement is made with the DUT in-line. Relative power is displayed by the meter in dB.

To perform relative power measurement (insertion loss), make sure to perform the "SET-UP FOR PDL, LOSS AND POWER MEASUREMENTS" section on page 22 and then, follow these steps:

1. Leave the meter in Relative Power mode. In this mode, the meter displays "RELATIVE POWER" on the lower part of the LCD and the reading (i.e. -0.15 dB) is displayed on the top of the display.
2. Press the ▲ or ▼ key to select the required output port.
3. Press the λ key to select the wavelength at which the measurement is to be made.
4. Clean the output connector of the measurement jumper and the input connector of the DUT, and connect the two together. Connect the output connector of the DUT to the detector on the front of the meter. The meter displays the loss due to the DUT (see Figure 11).
5. For measurements at additional wavelengths, repeat steps 3 to 5 for each desired wavelength.

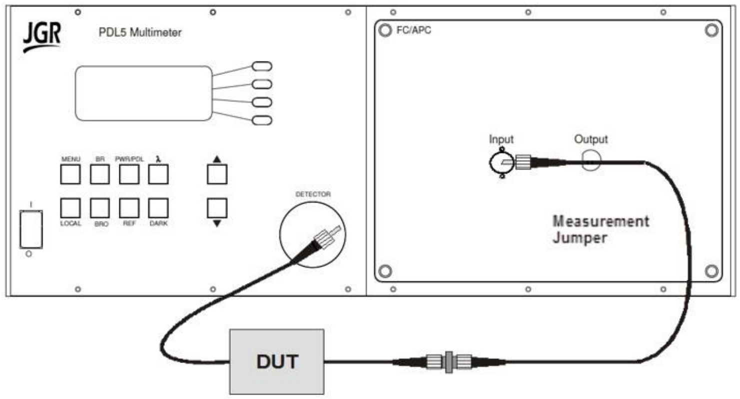

Figure 11: Measuring Relative Power (insertion loss)

Measuring ILa and Polarization Dependent Loss (PDL)

To perform ILavg and PDL measurement, make sure to perform the "SET-UP FOR PDL, LOSS AND POWER MEASUREMENTS" section on page 22 and then, follow these steps:

1. Press the PWR/PDL key to set the meter in ILavg and PDL measurement mode. The internal polarization controller will automatically start once this mode is selected. In this mode, the meter displays "ILa" and "PDL" and the reading for each measurement (i.e. -0.15 dB) is displayed after the label.
2. Press the ▲ or ▼ key to select the required output port.
3. Press the λ key to select the wavelength at which the measurement is to be made.
4. Clean the output connector of the measurement jumper and the input connector of the DUT, and connect the two together. Connect the output connector of the DUT to the detector on the front of the meter. The meter displays the DUT ILavg and PDL (see Figure 12).
5. For measurements at additional wavelengths, repeat steps 3 to 5 for each desired wavelength.

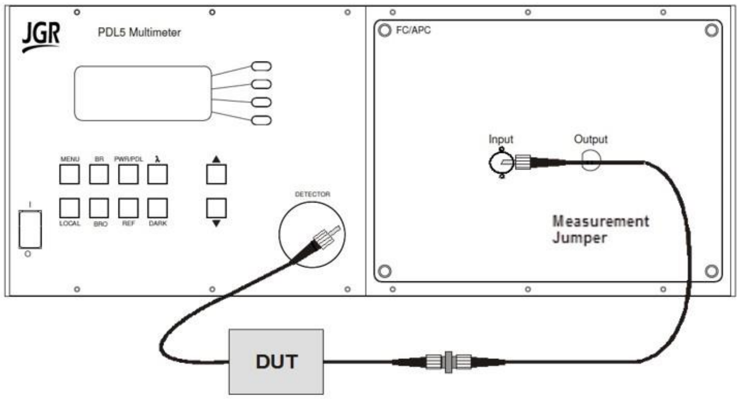

Figure 12: Measuring ILa and PDL

Power Accuracy

The absolute accuracy of power measurements made with the PDL5 meter is dependent on the power level to be measured. The PDL5 meter does not measure power levels below -50 dBm unless internal electronic noise is measured and its value, described by the dark current ID, is stored.

To ensure accurate power measurements below -60 dBm for 5mm Ge detectors and -80 dBm for 2mm InGaAs detectors, perform a Dark Current Measurement frequently. Refer to the “DARK CURRENT MEASUREMENT” section on page 24 for the procedure.

NOTE: The value of ID can change with temperature variations.

Termination Techniques

Termination is a term to describe the action of blocking all backreflection beyond a point in a network of components. The termination technique varies depending on the fiber type. There are two main termination techniques:

- **Mandrel wrap** consists of wrapping the fiber around a relatively small mandrel, causing attenuation in the fiber which prevents any reflected light after the mandrel from returning back to the meter. Mandrel wrapping is used exclusively on single-mode fiber since mandrel wrapping does not attenuate the lower order modes in multimode fiber (i.e. impossible to attenuate all the light in a multimode fiber using a mandrel wrap).

- **Index-Matching Medium** allows the light to escape the fiber through the end of the fiber (either bare fiber, or through a connector) with minimal reflections back to the meter. Index Matching Medium can be used on single-mode fiber if expected BR is not lower than -65dB (UPC connectors) and multimode fiber, but since it is less effective than mandrel wrapping, it is usually used on multimode fiber only. Remember that index matching medium cannot be used on single-mode fiber with APC connectors since expected BR of such connectors is below -65dB.

Termination of the fiber is critical. Stable and repeatable backreflection measurements will only be achieved with stable and repeatable termination of the fiber.

Mandrel Wrap Technique

As mentioned above, termination of single-mode fiber is most of the time performed by mandrel wrapping. Remember however that the index-matching technique described below could also be used for single-mode fiber with UPC connectors.

High-attenuation bends in the fiber (bends with a relatively small radius) remove all backreflection and can be made anywhere along the length of the cable. Typical mandrel diameters will be as follow:

- 13 mm for 1490, 1550, 1625 and 1650 nm
- 9 mm for 1310 nm with SMF-28 fiber
- 7 mm for 1310 nm with low bend sensitive SMF.

When measuring backreflection levels below -60 dB, low-attenuation bends (bends with a relatively large radius) need to be made just before the high-attenuation bends in order to offset the small amount of reflection caused by the high-attenuation bends.

1. Use the supplied rod and use the appropriate section depending on the fiber type as described above. The required number of turns will vary with BR_0 value of the PDL5 meter. Wind the Measurement jumper around the rod until BR_0 is at MAX and no longer decreases. For example, wind until BR_0 remains at -68dB MAX regardless of number of turns. Unwind until BR_0 goes below -68dB again and then add 1 turn. Count number of turns and use the same numbr of turn after your DUT for best BR accuracy.
2. To minimize any memory of the bends in the jumper jacket, do not pull on the jumper while winding, and occasionally wind it in the opposite direction.

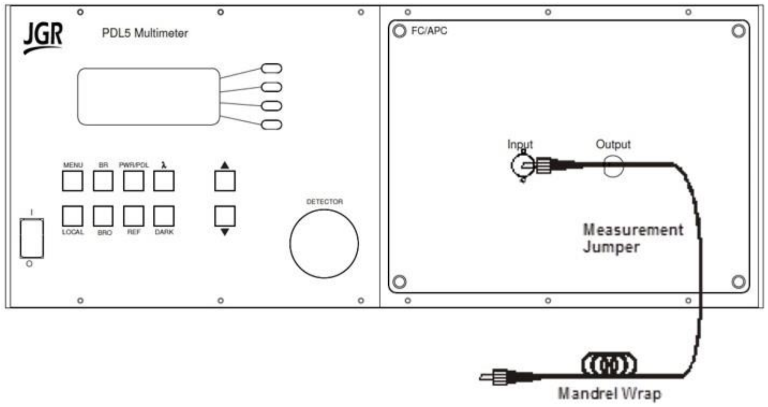

Figure 13: Mandrel Wrap Termination Technique

Remember also that index-matching technique described below can also be use on single-mode fiber with UPC connectors when expected BR is greater than -65dB.

User Menu Operation

Accessing the User Menu

To access the User Menu, simply press the "MENU" button. LED indicator will light.

User Menu options are detailed in Table 6.

Navigating the User Menu

- Access each option by pressing the corresponding softkey to the right of the display.
- Return to the main user menu at any time by pressing the MENU button.
- For the Transmission RATE and GPIB ADDR options, begin by selecting the option with the softkey, and use the up/down arrows to scroll through the numbers. Press the softkey again to exit from this mode.
- To exit and save changes, press the MENU button until prompted to "Quit?" or "Save?" Quitting exits the Menu Mode without saving changes. Selecting save will store the changes until they are overwritten by a new set of saved changes.

Table 6: User Menu Options

Options	***Note***
REMOTE MENU	
JGR COMMAND SETs	In remote control, the PDL5 Multimeter will be operated using the JGR command set described in Appendix B
BAUD RATE: ____ Default: 9600	Choose a rate between 300 and 38400 kbit/s
GPIB ADDR: __ Default: 21	Select a GPIB address between 01 and 30
OPTION MENU	
Compensate IL: ON/OFF Default: ON	Monitors and compensates for internal source drift
SETUPviaLOSS: ON/OFF Default: ON	Adjusts the BR measurement by compensating for loss at the connector. The measurement is taken during IL reference and offsets BR by twice this value.
PDL 6 State: ON/OFF Default: ON	Enables the 6-state Mueller matrix method. In OFF mode, 4-state matrix is used.
High Res.: ON/OFF Default: ON	3 decimal places in High-Res mode vs 2 decimal places in normal mode. Applies to Absolute and Relative Power, PDL and ILavg measurements.
Save? Quit?	Once changes are made the meter returns to the measurement mode.

Messages and Symbols

The messages/symbols displayed by the PDL5 meter are shown in Table 7.

Table 7: PDL5 Multimeter Display Messages and Symbols

Display	***Description***
PDL5 VER *X.XX*	Displayed momentarily during the power-up sequence and indicates the firmware version.
INITIALIZING	Displayed momentarily during the power-up sequence as the initial internal reference measurements are made
-XX.X dB BACKREFLECTION	Backreflection measurement mode
-XX.X * dB	???
-XX.XX dBm ABSOLUTE POWER	Absolute Power measurement mode
-XX.X X dB RELATIVE POWER	Relative Power measurement mode
ILa:-XX.XX dB PDL:-XX.XX dB	ILa and PDL measurement mode
<	P or BR is lower than the minimum measurable value
>	P is greater than the maximum measurable value
BR_0 STORED=-*XX.X*	Displayed momentarily when the BR value (-XX.XdB) is being stored as BR0.
Warning! BR_0 higher than normal!	Once changes are made the meter returns to the measurement mode.
All SetupViaLoss	Displayed momentarily after a reference has been taken for all wavelengths (by holding the reference button down for 2 seconds in BR mode)
X.XX dB Offset	Displayed momentarily when the SetupViaLoss function BR offset is taken.
Ref ALL WL	Displayed momentarily after a reference has been taken for all wavelengths (by holding the reference button down for 2 seconds in Absolute Power mode)
I-DARK MEASURING	Displayed momentarily when making a Dark

Display	*Description*
I-DARK STORED	measurement and once value has been stored
TOO MUCH LIGHT	Displayed momentarily if the dark current value (ID) value is too high.
LASER POWER LOW	Displayed momentarily when the laser power is too low.
LASER POWER HIGH	Displayed momentarily when the laser power is too high.
SOURCE UNSTABLE	Displayed momentarily when the laser power is unstable.

Calibration

⚠	**Caution** Devices with malfunctioning lasers must be returned to the manufacturer for repair.

Calibration should be performed by a qualified Calibration Laboratory. Power and Backreflection values of the PDL5 Multimeter are factory-set and must be periodically adjusted to maintain performance.

Calibration Period

JGR Optics recommends a 1 year calibration period for the PDL5 PDL/IL/BR Multimeter.

6

PROGRAMMING GUIDE

Setting up for RS-232, USB or GPIB communication

The PDL5 Series Multimeter may be remotely controlled via GPIB (IEEE-488) and RS-232 interface. The GPIB interface of the meter conforms to the ANSI/IEEE standards 488.1-1987 and 488.2-1987. The RS232C interface conforms to ANSI/IEEE standard 488.2-1987 where applicable.

The common command set conforms to ANSI/IEEE 488.2 standard syntax. All other commands conform to the Standard Commands for Programmable Instruments (SCPI) command language, version 1999.0.

Accessing the “User Menu” mode

In order to establish communication between the computer and the meter, the RS-232 bus or the GPIB bus must be configured properly. The different options for the communication are contained in the User Menu.

Programming over GPIB

The PDL5 multimeter supports the IEEE-488.1(1987) interface standard. It also supports the mandated common commands of IEEE-488.2(1987) standard. Before attempting to communicate with the meter over the GPIB interface, the device address must be set. The address is set by accessing the USER MENU function from the front panel.

Programming Over RS-232

In order to establish a serial communication between the computer and the PDL5, the computer’s COM port must be configured as described in Table 8.

To connect the PDL5 to the computer, a standard 9 pins straight RS-232 cable is required. Only three pins, Txd, Rxd and GND are needed.

Programming Over USB

It is also possible to remote control the PDL5 multimeter via USB by using a USB to DB9 adapter cable. The same RS-232 commands are used for USB communication.

Table 8: Serial Communication Settings

Transmission Rate	Selectable in the "User Menu". Available options are 1200, 2400, 4800, 9600, 19200 and 38400 bps
Data bit	8
Parity	N
Stop bits	1
Flow Control	None

7

MAINTENANCE AND TROUBLESHOOTING

Maintenance

⚠	**Warning** Devices with malfunctioning lasers must be returned to the manufacturer for repair.

Cleaning the Unit

1. Unplug the unit from the line power.
2. Clean the enclosure with a damp cloth.
3. Do not plug the unit back until it is completely dry.

Cleaning the Connector Ends

1. Clean all connector ends with a lint-free tissue and alcohol before every mating. See the “CLEANING CONNECTORS” section on page 36.
2. Loosen the retaining screws of the connector panel, and remove the panel carefully to access the internal connectors (Figure 15).
3. Remove the connector from the mating sleeve in the panel.
4. Clean the connector end faces and mating sleeve in accordance with the “CLEANING CONNECTORS” Section on page 36.
5. Reinstall the connector onto the panel.
6. Reinstall the connector panel. To avoid damaging the input and output port fibers, make one or two large loops in the fibers when reinstalling the panel.

Figure 14: Removing Connector Panel

Cleaning Jumper Connectors

	**Warning** Connecting damaged or dirty fibers to the unit can damage the front-panel connectors of the unit. Never force an optical connector. Some connectors have a ceramic ferrule that can easily be broken.

Optical cable ends need to be cleaned before using them with the unit. The following items are required for cleaning the connector:

- Filtered compressed air or dusting gas
- Lint-free swab and lint-free towels
- Optical grade isopropyl alcohol or optical grade 200° ethanol **(do not use rubbing alcohol, which contains 30% water)**

To clean the connectors:

1. Blow the sleeve with filtered compressed air.
2. Apply optical grade isopropyl alcohol or optical grade ethanol to a small area of a lint-free towel and rub the end of the ferrule over the wet area.
3. Wipe the ferrule on a dry area of the lint-free towel.
4. Using the dusting gas or compressed air, blow the end of the ferrule.
5. Apply the alcohol or ethanol to a lint-free pipe cleaner or swab and wipe off the remaining parts of the connector.
6. With the other end of the pipe cleaner or swab, dry the areas cleaned.

7. Using the dusting gas or compressed air, blow the areas cleaned.

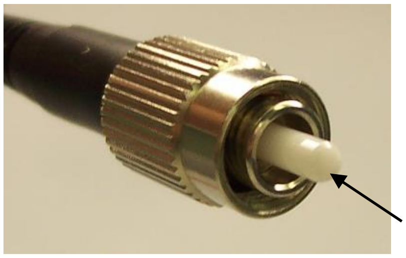

Figure 15: Connector (Connector Type May Vary)

Troubleshooting

If any problem described in this section persists, contact JGR Optics or your local representative.

Connector Issues

Front Panel Connectors

Follow the maintenance procedure described in the section: "CLEANING THE CONNECTOR ENDS" section on page 35, to ensure that the internal pigtail connectors are clean and properly connected to the front panel mating sleeve.

If cleaning is not sufficient, the FC/APC connector can be polished.

Connector Loss and Backreflection

Ensure that the insertion loss and backreflection of all the connectors are low and stable, complying with the connector specifications.

PDL5 Calibration Issues

To verify PDL5 calibration, follow the procedure below. If results are different than those indicated, please contact JGR Optics to have your unit calibrated.

1. Make sure to clean front panel connector. Refer to the "CLEANING CONNECTOR ENDS" section on page 35.
2. Turn PDL5 meter to ON
3. Leave meter in BR measurement mode
4. Verify the calibrated jumper to make sure it is not damaged and that all connectors are cleaned. Refer to the "CLEANING JUMPER CONNECTORS" section on page 36 if necessary.
5. Connect the APC end of the calibrated jumper to the APC connector of the source

6. Connect the FC/UPC end to the detector adapter
7. Select Absolute mode
8. Make sure that output power is above -10 dBm for all laser sources
9. Take an IL reference for each wavelength. Select Relative mode by pressing and holding the Power button until zero.
10. Select BR mode
11. Terminate the calibrated jumper by applying a mandrel wrap in the middle
12. Verify BR readings to be below -65 dB for all wavelengths
13. Release the mandrel wrap and verify that BR value is within the following ranges: 14.7 dB ± 0.4 dB for 1310 nm and 14.8 dB ±0.4 dB for 1490, 1550 and 1625 nm for single-mode fiber and 14.4dB +/- 0.4dB at 850nm 14.5dB +/- 0.4dB at 1310nm for multimode fiber.

Loss and Reflection issues

Backreflection measurement accuracy is greatly impacted by losses before the DUT and by reflections before and after the DUT.

Losses before the DUT

When a DUT is connected to the PDL5 PDL/IL/BR Multimeter, insertion loss of the connectors before the DUT affects the backreflection reading. As light travels from the PDL5 Multimeter and returns, it goes through the connectors twice, so the effect of the losses is doubled. If the insertion loss is close to 0.15 dB, its effect is compensated automatically by the meter. If the insertion loss differs substantially from 0.15 dB, follow the measurement procedures described at the end of the LOSS AND POWER MEASUREMENTS" section on page 22.

Reflections before the DUT

When a device is connected to the PDL5 Multimeter, the reflections from the connectors affect the backreflection reading. The front panel FC/APC connections must have backreflection levels below -65 dB for single-mode (-45 dB for multimode). To ensure that the PDL5 Multimeter automatically compensates for backreflections, follow the set-up procedure described in the "BACKREFLECTION MEASUREMENTS" section on page 17, and ensure that the backreflection does not change from the time of the setup.

Reflections after the DUT

When making a backreflection measurement, the fiber after the DUT must be terminated to eliminate the reflections from the end of the fiber (see the "TERMINATION TECHNIQUES" section on page 27). For the greatest accuracy when making very low backreflection measurements, terminate the fiber near the DUT to eliminate reflections from the fiber itself.

Long Cables (for single-mode model only)

Terminate the cables near the devices or connectors being tested in order to eliminate backreflection from the fiber.

Laser Stability

If the message “Source Unstable” or “LASER POWER LOW” is displayed, remove the front connector panel, clean the front panel connectors, connect the internal FC/APC connector to the detector adapter, and press the Power key to set the meter to Power mode. The reading must be steady and higher than -10 dBm. If not, perform the procedure recommended in Table 9 when this message is displayed.

Polarization Controller Issues

If the waveplates can't be moved to 0 position on start-up, or the communication is lost with any of the driver boards, the following message will appear: "WP MOTOR FAIL !".

If this message is displayed, there is a problem with the polarization controller. Please contact JGR Optics for support.

Table 9: Front Panel Display Function

Display	***Problem***	***Solution***
	Meter does not turn on	Turn OFF the unit. Connect the PDL5 meter to a reliable power source, and wait a few minutes. Turn the unit ON.
INITIALIZING	Message is displayed for a long time	Turn OFF the unit. Connect the PDL5 meter to a reliable power source, and wait a few minutes. Turn the unit ON.
*	Backreflection measurement is getting close to PDL5 meter limit	Follow the setup and measurement techniques described in the "SETTING UP THE METER FOR BACKREFLECTION MEASUREMENTS" section
<	BR range is very limited	Follow the setup and measurement techniques described in the "SETTING UP THE METER FOR BACKREFLECTION MEASUREMENTS" section
TOO MUCH LIGHT!	Dark current (ID) value is too high	Attach the detector cap to the detector, and press the ID key.
LASER POWER LOW	Laser power is too low	Check the measurement setup for possible source of light being reflected back to the output port of the source.
LASER POWER HIGH	Laser power is too high	Check the measurement setup for possible source of light being reflected back to the output port of the source.
WP MOTOR FAIL !	Problem with waveplate motor or communication with the driver board	Please contact JGR Optics for support.

8

STORAGE AND SHIPPING

Damage can occur from improper handling during storage or shipping. Make sure to maintain the unit within the specified temperature range during storage or shipping. Please follow the recommendations below to minimize the possibility of damage:

If possible, pack the unit in its original packing material when shipping;

Avoid high humidity or large temperature fluctuations that cold generate condensation within the unit.

Avoid unnecessary shocks and vibrations.

Returning Instruments to JGR Optics

As indicated above, please ship the returned material in the original shipping box and packing material. If these are not available, follow the guidelines below:

1. Contact JGR Optics to obtain a RMA number;
2. Cover the front panel with foam to prevent damage;
3. Wrap the unit in anti-static packaging. Use anti-static connector covers;
4. Pack the unit in a strong enough shipping box considering the unit's weight;
5. Use enough shock-absorbing material (10 to 15 cm) to cushion the unit and prevent it from moving inside the box. Pink poly anti-static foam is recommended;
6. Seal the shipping box securely;
7. Clearly mark FRAGILE on at least 3 of the 4 sides of the box;
8. Always provide the model and serial number of the unit and, if necessary, the RMA number on any accompanying documentation. If possible, indicate the RMA number on the box itself to facilitate identification.

Contact Information

JGR Optics Inc.
160 Michael Cowpland Drive
Ottawa, Ontario, Canada
K2M 1P6

Phone: 613-599-1000
Fax: 613-599-1099
sales@jgroptics.com
www.jgroptics.com

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SPECIFICATIONS

Specifications are provided here as a reference only and may be changed without notice. Please refer to JGR Optics's website for the most recent specifications.

OPTICAL / ELECTRICAL SPECIFICATIONS				
Parameter	**Specification**			
Fiber Type (µm)	SMF-28e (9/125)			
Operating Wavelengths (nm)	1310 / 1490 / 1550 / 1625 / 1650/ Ext[1]			
Detector Type	Low PDL Ge		Low PDL InGaAs	Cavity
	3 mm	5 mm	1.5 mm	1 mm
Power Range (dBm)	5 to -65	5 to - 60	5 to - 80	5 to -50
PDL Accuracy[2]				
1310/1490/1550 nm	± (0.004 + 2% of PDL) typ ± (0.010 + 5% of PDL) max		± (0.020 + 2% of PDL) typ ± (0.025 + 5% of PDL) max	± (0.006 + 2% of PDL) typ ± (0.010 + 5% of PDL) max
1625 nm	± (0.010 + 2% of PDL) typ ± (0.015 + 5% of PDL) max		± (0.025 + 2% of PDL) typ ± (0.030 + 5% of PDL) max	± (0.006 + 2% of PDL) typ ± (0.010 + 5% of PDL) max
1650 nm	± (0.015 + 2% of PDL) typ ± (0.020 + 5% of PDL) max		N/A N/A	± (0.006 + 2% of PDL) typ ± (0.010 + 5% of PDL) max
PDL calculation method	4- or 6-state Mueller Matrix Method			
PDL Dynamic Range (dB)	> 3			
Absolute Power Accuracy (dB)[3,4]	± 0.25			
Relative Power Accuracy IL or IL_{ave}(dB)[5]	±(0.020 + 2% of IL or IL_{ave}) typical			
IL, IL_{ave} and PDL Resolution(dB)	0.01 or 0.001			
IL_{ave}/PDL Measurement time (s), typ[6]	0.7 (4-states, 0.01 res.) / 1.2 (6-states, 0.001 res)			
Backreflection Range (dB)	0 to - 80			
Backreflection Accuracy (dB)[4]	± 0.4[4,7]			
Backreflection Resolution(dB)	0.1			
Remote Interface	GPIB / RS232 / USB[8]			
Input Voltage	100 - 240 V AC, 50 - 60 Hz			
Power Consumption (VA)	80 maximum			
Display	4 lines, 16 character per line, LCD			

[1] Low coherence length source (FP, SLED) with isolation is recommended to meet the specs.

[2] For PDL values below 0.5 dB, 6 states method, 0.001 dB resolution, non-angled connector. Higher PDL values may reduce the measurement accuracy.

[3] Measured at -10 dBm.

[4] At calibrated discrete wavelengths.

[5] Referenced and measured with a non-angled connector with the same detector adapter and detector.

[6] For low PDL (<0.5 dB) and IL (<15dB) values. Certain other conditions (eg. fiber movement) may also increase measurement times.

[7] Add 0.1 dB to the spec for every 1dB below -60dB.

[8] USB interface via-USB-DB9 adapter.

MECHANICAL / ENVIRONMENTAL SPECIFICATIONS	
Parameter	Specification
Unit Dimensions W x H x D (cm)	36 x 15 x 34
Shipping Box Dimensions W x H x D (cm)	43 x 27 x 47
Unit Weight (kg)	9
Total Shipment Weight (kg)	10
Operating Temperature (°C)	0 to 40
Storage Temperature (°C)	- 40 to 70
Humidity (Non-condensing) (°C)	Maximum 95% RH from 0 to 40

B

REMOTE CONTROL COMMANDS

Command Syntax and Style

Program Message Formats

A program message consists of a command header, followed by its required parameters. The parameters must be separated from the command header by a space, for example, ***ESE 10**. Multiple parameters must be separated by a comma (,).

Each program message can contain one or more message units. The message units in a program message must be separated by a semicolon (;), for example, ***CLS;*ESE 10**.

Terminating a Program Message

The command terminator should be a linefeed <LF> plus EOI for GPIB, and a carriage return <CR> plus a linefeed <LF> for RS-232. No command processing occurs until a command terminator is received.

Command Header Variations

Each command header in the command tree has a long form and a short form. Both forms are acceptable and each form gives an identical response.

Examples:

:SOURCE:WAVELENGTH 1310

:SOUR:WAV 1310

:STATUS:OPERATION:ENABLE 255

:STAT:OPER:ENAB 255

The query form of a command must end with a question mark (?). A command can be entered in either uppercase characters or lowercase characters.

Specifying the Command Path

In order to use a command in the command tree, the meter must know the full path to the command. If the command is the first command in the program message, the command header must contain the full path to the command. Subsequent commands in the same program message are automatically referenced in the same path as the previous command, unless a colon (:) precedes the command's command header, in which case the full path to the command must be included in the command header.

[:SOURce]

:WAVelength <wavelength>

The following program messages are valid:

SOUR:WAV 1310;WAV?

SOUR:WAV 1310;:SOUR:WAV?

STAT:OPER:ENAB 5;ENAB?

The following program messages are **NOT** valid:

SOUR:WAV 1310;SOUR:WAV?

(no colon before second command)

CHAN:NEXT;CHAN?

(CHAN command at different level than NEXT)

Default Commands

Default commands are commands that do not need to be explicitly included in the command path. If a default command for a path exists, it is enclosed by square brackets ([ ]) in the command tree. If a default command is implied in the first command of a program message, the command path for subsequent commands is determined as if the default command had been explicitly included in the first command header.

[:SOURce]

:WAVelength <wavelength>

The following program messages are valid:

SOUR:WAV 1310

WAV 1310

Implemented Status Structures

PDL5 multimeter has the following status data structures implemented:

IEEE 488.2 defined standard registers (standard status structure)

The 488.2 standard status structure consists of four registers:

- status byte register
- service request enable register
- standard event status register
- standard event status enable register

Note that the standard event status register and the event register are both "sticky" (i.e. once their bits are set to 1 they remain set until they are cleared by appropriate commands). The status byte register and the condition register are both dynamic and get updated when the state of the instrument or the underlying status structures change. Refer to IEEE488.2 and SCPI1999 documents for further details.

Status Byte Register

The status byte register contains the summary bits for each of the structures implemented in the meter, the master summary bit (MSB) and the request for service bit (RQS).

Status Register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
operation summary bit (OSB)	request for service *or* master summary	event summary (ESB)	message available (MAV)	(QSB) not used	not used	not used	not used
Read with		By serial polling ***STB?**					
Written to with		Cannot be written to					
Cleared by		***CLS** common command					

- Bit 0 to Bit 3 are not used.
- Bit 4 (message available) is set to 1 when a response message is available in the output queue.
- Bit 5 (event summary bit) is the summary bit for the standard event status structure. The ESB summary message bit is set if any bit in the standard event status register is set while its corresponding value in the standard event status enable register is set.
- Bit 6, as the service request bit, is set to 1 if a service request has been generated.

  Bit 6, as the master summary bit, is set when there is at least one reason for the meter to request service from the controller. That is, the master summary bit is set if any summary bit in the status byte register is set and if the corresponding bit in the service request enable register is also set.
- Bit 7 (operation summary bit) is the summary bit for the operation status register. It is set if any bit in the operation event register is set while the corresponding bit in the operation event enable register is set.

Service Request Enable Register

The service request enable register determines which summary bits in the status byte register can generate service requests. If a summary bit in the status register is set to 1 and the corresponding bit in the service request enable register is set to 1, a service request is generated by the meter. A new service request is not generated for this condition unless the bit in the status register or the bit in the service request enable register is cleared and the condition reoccurs.

Service Request Enable Register	
Read with	***SRE?** common query (the value of bit 6 is always 0)
Written to with	***SRE** common command (the value of bit 6 is always zero, regardless of the value sent with the command)
Cleared by	***SRE** common command with a parameter value of 0 Power-on

Standard Event Status Register

Standard Event Status Register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
power on (PON)	user request (URQ)	command error (CME)	execution error (EXE)	device dependent error (DDE)	query error (QYE)	request control (RQC)	operation complete (OPC)
Read with		***ESR?** common query					
Written to with		Cannot be written to					
Cleared by		***ESR?** common query ***CLS** common command Power-on					

- Bit 0 (operation complete) is set in response to the ***OPC** common command. This bit is set when all operations are complete.
- Bit 1 (request control) is always set to 0.
- Bit 2 (query error) is set when a query error occurs, for example, an attempt is made to read the output queue when the output queue is empty or when the data in the output queue is lost.
- Bit 3 (device dependent error) is set by the meter to indicate that an error has occurred that is not a command error, an execution error, or a query error.
- Bit 4 (execution error) is set when an execution error is detected by the meter, for example, if a command parameter is out of the range of the meter or a valid program message cannot be executed due to some condition in the meter.
- Bit 5 (command error) is set when a command error is detected by the meter, for example, if a syntax error is detected in a program message, an incorrect command header is received, or if an IEEE GET message is received in the middle of a program message.
- Bit 6 (user request) is always set to 0.

- Bit 7 (power on) is set when an off-to-on transition occurs in the power supply of the meter.

Standard Event Status Enable Register

The contents of the standard event status enable register determine which events in the standard event status register are reflected in the event summary bit (ESB) of the status byte register.

Standard Event Status Enable Register	
Read with	***ESE?** common query
Written to with	***ESE** common command
Cleared by	Power-on ***ESE** common command with a parameter 0

Queues

Input Queue

The input queue in the meter is a first-in-first-out (FIFO) queue and is 128 characters in length. Data bytes received from the controller are placed in the input queue in the order received. When a full message meter is received, it is transferred to the parser.

If the input queue becomes full while the GPIB is being used, the data acknowledge signal (DAQ) is not sent to the GPIB controller until a character is transferred from the input buffer to the parser. This ensures that no bytes in the program message are lost. However, the RS232C interface has no DAQ signal and cannot be signaled when the input queue becomes full. Therefore, characters sent to the PDL5 Meter are lost.

If a new program message is received before the response to a query in a previous message is read, the output queue is cleared, MAV is set to false, and the query error bit is set. This error is also referred to as an unterminated error.

Output Queue

Responses to query messages are placed in the output queue. This queue is 128 characters in length. When a response is placed in the output queue, the MAV bit in the status register is set. The MAV bit is cleared when the response is sent.

Response messages are always terminated with the sequence <LF> and, if the response is being sent through the GPIB, the EOI signal is set to true when the last character in a response is sent.

If an attempt is made to read the output queue when it is empty and the current program message does not contain a query, a query error bit is set.

Error Queue

The error queue is where error messages are stored and it can contain up to 10 messages. Because it is a FIFO queue, the error returned when the error queue is read is always the first error that occurred.

If more than 10 errors are put in the error queue, an overflow error occurs and the last error in the queue is overwritten with error number -350 (Queue Overflow). Each error in the queue consists of an error number and a brief error message.

Description of Error Numbers

0	No error

No error has occurred.

-100	Command error

A command error was detected, but the parser cannot be more specific.

-130	Suffix error

An error was detected in the suffix sent with the command, but the parser cannot be more specific.

-220	Parameter error

An error was detected in a parameter, but the control block cannot be more specific.

-240	Hardware error

A hardware error was detected, but the control block cannot be more specific.

-330	Self-Test error

The device failed a self-test.

-350	Queue overflow

The error queue has overflowed, and an error has occurred that cannot be recorded.

-400	Query error

A query error was detected, but the parser cannot be more specific.

IEEE 488.2 Common Commands and the SCPI Command Tree

IEEE 488.2 Common Commands

Command	Parameter	Response	Minimum	Maximum
*CLS	N/A	N/A	N/A	N/A
*ESE	Integer	N/A	0	255
*ESE?	N/A	Integer	0	255
*ESR?	N/A	Integer	0	255
*IDN?	N/A	String	N/A	N/A
*OPC	N/A	N/A	N/A	N/A
*OPC?	N/A	Integer	1	1
*RST	N/A	N/A	N/A	N/A
*SRE	Integer	N/A	0	255
*SRE?	N/A	Integer	0	255
*STB?	N/A	Integer	0	255
*TST?	N/A	Integer	0	1
*WAI	N/A	N/A	N/A	N/A

SCPI Command Tree

All commands other than the IEEE 488.2 common commands are listed in the following table.

Command	Parameters	Response
[:SOURce]		
:WAVlength	Num Val| MIN|MAX|DEF	
:WAVlength?	None|MIN|MAX|DEF	Num Val
[:NEXT]		
:CHANnel	Num Val|MIN|MAX	
:CHANnel?	None|MIN|MAX	Num Val
[:NEXT]		
[:POWer]		
:MODe	ABS|REL|BRM|PDL	
:MODe?		ABS|REL|BRM|PDL
:READ?		Num Val
:FULL?		Num Val, String
:DETector	Num Val| MIN|MAX	
:DETector?	None|MIN|MAX	Num Val
[:NEXT]		
:DARK		
:BR0		
:READ?		Num Val
:STORe		
:CLEar		
:ALL		
:SVL		
:READ?		Num Val
:CLEar		
:ALL		
:REFerence		
:AWL		
:INIT		
:CONT	Num Val, String	

:CONT?		Num Val, String
:SYSTem		
:ERRor[:NEXT]?		Num Val, String
:VERSion?		String
:CAPability?		String
:COMMunicate :GPIB [:SELF] :ADDRess	Num Val	
:COMMunicate :GPIB [:SELF] :ADDRess?		Num Val

Description of Individual Commands

IEEE-488.2 Common Commands

Clear Status Command

Syntax	*CLS
Function	Clears the following queues and registers: • Error queue • Standard event status register • Status byte register • Operation event register • Questionable event register If ***CLS** is sent immediately after a message terminating sequence, both the output queue and the MAV bit in the status byte register are cleared.
Example	*CLS

Standard Event Status Enable Register Command

Syntax	***ESE**<space><numeric value> where 0 ≤ <numeric value> ≤ 255
Function	Sets the bits in the standard event status enable register. The numeric value is converted to a binary number. The bits of the register are set to match the bit values of the binary number.
Example	***ESE 97** sets the standard event status enable register bits to 01100001.

Standard Event Status Enable Register Query

Syntax	*ESE?
Function	Returns the contents of the standard event status enable register as an integer that, when converted to a binary number, represents the bit values of the register.
Example	***ESE?** returns 97 if the standard event status enable register is set to 01100001.

Standard Event Status Register Query

Syntax	*ESR?
Function	Returns the contents of the standard event status register as an integer that, when converted to a binary number, represents the bit values of the register. The standard event status register is cleared after ***ESR?** command.
Example	***ESR?** returns 195 if the standard event status register is set to 11000011.

Identification Query

Syntax	*IDN?
Function	The ***IDN** query returns a string value which identifies the manufacturer, instrument type and firmware version.
Example	***IDN?** Returns "JGR Optics Inc., PDL5, XXXXXXX, Y.YY" **Where:** <XXXXXXX> = device serial number <Y.YY> = firmware revision number

Operation Complete Command

Syntax	*OPC
Function	Causes the meter to set the OPC bit in the standard event status register when all pending operations have been completed.
Example	*OPC

Operation Complete Query

Syntax	*OPC?
Function	Places a “1” in the output queue of the meter when all pending operations have been completed. Because the “1” is not always placed in the output queue immediately, the status byte register should be polled and the MAV bit checked to determine if there is a message available in the output queue.
Example	*OPC?

Reset Command

Syntax	*RST
Function	Meter is reset to the power-on condition.
Example	*RST

Service Request Enable Command

Syntax	***SRE**<space><numeric value> where 0 ≤ <numeric value> ≤ 63 and 128 ≤ <numberic value> ≤ 191.
Function	Sets the bits in the service request enable register. The numeric value is converted to a binary number. The bits of the register are set to match the bit values of the binary number.
Example	***SRE 154** sets the service request enable register bits to 10011010.

Service Request Enable Query

Syntax	*SRE?
Function	Returns the contents of the service request enable register as an integer that, when converted to a binary number, represents the bit values of the register.
Example	***SRE?** returns 154 if the service request enable register is set to 10011010.

Read Status Byte Query

Syntax	*STB?
Function	Returns the contents of the status byte register as an integer that, when converted to a binary number, represents the bit values of the register. The bit value for bit 6 of the register is the MSS bit value, not the RQS bit value.
Example	***STB?** returns 170 if the status byte register is set to 10101010.

Self-Test Query

Syntax	*TST?
Function	Initiates a self-test of the meter and returns 0 if the meter passes the self-test or 1 if it fails.
Example	*TST?

*WAI Command

Syntax	*WAI
Function	Prevents the meter from executing any further commands or queries until all previously pending operations have been completed. There are no consequences to this command because all commands are executed sequentially; therefore, any subsequent commands are completed by the time this command is parsed.
Example	*WAI

SCPI Commands

[:SOURce]:WAVlength

Syntax	[:SOURce]:WAVlength<space>[wavelength|MIN|MAX|DEF] OR [:SOURce]:WAVlength[:NEXT]
Function	Switches to a specified or next available wavelength. • **no parameter or [:NEXT]:** switches to the next available wavelength • **wavelength:** switches to the specified wavelength in nm. Other units can be specified • **MIN, MAX or DEF:** switches to the first, last or default wavelength respectively.
Example	**WAV 1.55 um** switches the meter's output to 1550 nm.

[:SOURce]:WAVlength?

Syntax	[:SOURce]:WAVlength?<space>[MIN|MAX|DEF]
Function	Returns the current or specified output source wavelength in nm • **No parameter:** returns the current wavelength • **MIN, MAX or DEF:** returns the first, last or default wavelength respectively.
Example	**WAV? MIN** returns: 1310.

[:SOURce]:CHANnel

Syntax	[:SOURce]:CHANnel<space>[channel_number|MIN|MAX] OR [:SOURce]:CHANnel[:NEXT]
Function	Switches the source output to a specified channel number • **no parameter or [:NEXT]:** switches to the next channel number • **channel_number:** switches to the specified by the parameter channel number • **MIN or MAX:** switches to the first or last configured channel number respectively.
Example	**CHAN 3** switches the meter to channel 3.

[:SOURce]:CHANnel?

Syntax	[:SOURce]:CHANnel?<space>[MIN|MAX]
Function	Returns the current or specified channel number • **No parameter:** returns the current channel number • **MIN or MAX:** returns the first or last configured channel number.
Example	**CHAN?** returns: 3.

[:POWER]:MODe

Syntax	[:POWER]:MODe<space>[ABS|REL|BRM|PDL]
Function	Switches the meter between the following operation modes: • **ABS:** absolute power operation mode • **REL:** relative power operation mode • **BRM:** backreflection operation mode • **PDL:** IL avg and PDL operation mode.
Example	**MOD PDL** switches the meter into ILavg and PDL mode

[:POWER]:MODe?

Syntax	**[:POWER]:MODe? (note: v1.00 doesn't return PDL due to a bug)**
Function	Returns the current operation mode.
Example	**MOD?** returns: ABS.

[:POWER]:READ?

Syntax	[:POWER]:READ?
Function	Triggers and Returns the reading of the meter
Example	**READ?** returns -55.2 (the unit is in BR mode).

[:POWER]:READ:FULL?

Syntax	[:POWER]:READ:FULL?
Function	Returns the current reading (power or BR) of the meter, the current channel number, detector number and output wavelength (in non-PDL mode).
Example	**READ:FULL?** returns -55.2, 5, 0, 1310 (the unit is in BR mode).

[:POWER]:DETector[:NEXT]

Syntax	[:POWER]:DETector<space>[detector_number|MIN|MAX] OR [:POWER]:DETector[:NEXT]
Function	Switches to the specified detector number • **no parameter or [:NEXT]:** switches to the next detector number • **detector_number:** switches to the specified by the parameter detector number • **MIN or MAX:** switches to the first or last configured detector number respectively.
Example	**DET 2** switches to the detector number 2.

[:POWER]:DETector?

Syntax	[POWER]:DETector?<space>[MIN|MAX]
Function	Returns the current or specified detector number • **No parameter:** returns the current detector number • **MIN or MAX:** returns the first or last configured detector number.
Example	**DET?** returns: 2.

[:POWER]:DETector:DARK

Syntax	[:POWER]:DETector:DARK
Function	Measures and stores the custom ID value used in dark measurements for all available detectors.
Example	**DET:DARK** takes the dark current measurement for all detectors.

[:POWER]:BR0:READ?

Syntax	[:POWER]:BR0:READ?
Function	Returns the current BR_0 value (custom or factory stored).
Example	**BR0:READ?** returns: -65.5.

[:POWER]:BR0:STORe?

Syntax	[:POWER]:BR0:STORe
Function	Measures and stores the custom BR_0 measurement for the current source wavelength and output channel.
Example	**BR0:STOR** measures and stores the custom BR_0 value.

[:POWER]:BR0:CLEAR

Syntax	[:POWER]:BR0:CLEAR
Function	Clears the custom BR_0 value for the current source wavelength and output channel.
Example	**BR0:CLEAR** clears the custom BR_0 value

[:POWER]:BR0:CLEAR:ALL

Syntax	[:POWER]:BR0:CLEAR:ALL
Function	Clears the custom BR_0 value for all source wavelengths and all output channels
Example	**BR0:CLEAR:ALL** clears all custom BR_0 value

[:POWER]:SVL:READ?

Syntax	[:POWER]:SVL:READ?
Function	Returns the current setup via loss value or 0.
Example	**SVL:READ?** returns: 0.15

[:POWER]:SVL:CLEAR

Syntax	[:POWER]:SVL:CLEAR
Function	Clears the setup via loss value for the current source wavelength and output channel.
Example	**SVL:CLEAR** clears the setup via loss value

[:POWER]:SVL:CLEAR:ALL

Syntax	[:POWER]:SVL:CLEAR:ALL
Function	Clears the setup via loss values for all source wavelengths and all output channels
Example	**SVL:CLEAR:ALL** clears all setup via loss values

[:POWER]:REFerence

Syntax	[:POWER]:REFerence
Function	Takes a relative power reference at current detector, current wavelength and current channel.
Example	**REF** takes the reference.

[:POWER]:REFerence:AWL

Syntax	[:POWER]:REFerence:AWL
Function	Takes a relative power reference at current detector with current channel, for all wavelengths.
Example	**REF:AWL** takes the reference for all wavelengths.

[:POWER]:REFerence:ALL

Syntax	[:POWER]:REFerence:ALL
Function	Takes a relative power reference at current detector for all wavelengths and all channels.
Example	**REF:ALL** takes the reference for all wavelengths and all channels

:INIT:CONT

Syntax	:INIT:CONT<space>[0|1] OR [OFF|ON]
Function	Sets the measurement mode to triggered or continuous. Primarily to be used with PDL mode.
Example	**:INIT:CONT** 0 turns OFF the continuous mode (triggered mode ON).

:INIT:CONT?

Syntax	:INIT:CONT?
Function	Returns a value which indicates whether the meter is in a triggered or continuous measurement mode.
Example	**:INIT:CONT?** returns: 0, the meter is in triggered mode.

:SYSTem:ERRor?

Syntax	:SYSTem:ERRor?
Function	Returns the error number and an error message from the error queue. See the **Error Queue** section, for a list of error numbers and their associated messages.
Example	**:SYST:ERR?** returns: 0, “No error”.

:SYSTem:VERSion?

Syntax	:SYSTem:VERSion?
Function	Returns the formatted numeric value the of the SCPI version number.
Example	**:SYST:VERS?** returns: 1999.0**.**

:SYSTem:CAPability?

Syntax	:SYSTem:CAPability?
Function	Returns the string specifying the capability of the device.
Example	**:SYSTem:CAPability?** returns: OPTICAL INSTRUMENT

:SYSTem:COMMunicate:GPIB[:SELF]:ADDRess

Syntax	:SYSTem:COMMunicate:GPIB[:SELF]:ADDRess<space><numeric_value>
Function	Sets the GPIB address. The factory-set GPIB address is 21. When the address is changed, the interface immediately responds to the new address.
Example	:SYST:COMM:GPIB:ADDR 7

:SYSTem:COMMunicate:GPIB[:SELF]:ADDRess?

Syntax	:SYSTem:COMMunicate:GPIB[:SELF]:ADDRess?
Function	Returns the GPIB address.
Example	:SYST:COMM:GPIB:ADDR? returns 7.

JGR Legacy Device Specific Commands

Table 10: Device-Specific Command List

PDL SPECIFIC COMMANDS	
PDL	Switch to PDL mode
PDL?	Query PDL value only. Non-triggered command
LAV?	Query Average loss value only. Non-triggered command
FP	Actuate Flip-in Polarizer
STATENUM	Change the number of polarization states for PDL mode
RES	Change the display resolution of PDL and PW modes
T	Switch between triggered and continuous mode
TRIG	Trigger a measurement
OTHER COMMANDS	
ABS	Switch to Absolute power mode
REL	Switch to Relative power mode
BRM	Switch to BR mode
MODE?	Query the current operation MODE
SWL	Switch Wavelength
SSC	Switch Wavelength by Sequence
SCH	Switch Channel
DET	Switch Detector
BRZS	Store BR0 (BR Zero Store)
BRZC	Clear BR0 (BR Zero Clear)
DARK	Store Dark Current
TREF	Take relative power Reference
TMF	Transmit a Measurement in Full format
TDO	Transmit Data Only
LCL	Return to Local control

JGR Device-Specific Command Description

PDL	The PDL command will switch the meter to PDL mode.
Interface:	GPIB and RS-232/USB
Syntax:	“PDL”<CR>
Returned Format:	None

PDL?	The PDL? command will cause the meter to transmit the last PDL value. In triggered PDL mode this command will not initiate a new measurement cycle. Use together with TRIG in triggered mode to obtain a new reading.
Interface:	GPIB and RS-232/USB
Syntax:	“PDL?”<CR>
Returned Format:	“xx.xx” or “xx.xxx” depending on resolution

LAV?	The LAV? command will cause the meter to transmit the last Average Loss value. In triggered PDL mode this command will not initiate a new measurement cycle. Use together with TRIG in triggered mode to obtain a new reading.
Interface:	GPIB and RS-232/USB
Syntax:	“LAV?”<CR>
Returned Format:	“xx.xx” or “xx.xxx” depending on resolution

FP	The FP command will move the Flip-In Polarizer IN or OUT of the optical path.
Interface:	GPIB and RS-232/USB
Syntax:	“FP x”<CR> Where x is a numeric value [0|1] OR a string [OFF|ON], stating whether the polarizer is in the path or not. Example “FP ON” moves the Flip-In Polarizer into the optical path
Returned Format:	None

FP?	The FP? command queries the state of the Flip-In Polarizer. The query returns 0 or .
Interface:	GPIB and RS-232/USB
Syntax:	“FP?”<CR>
Returned Format:	<x><NL> where <x> = 0 (out of the path) or 1 (in the path)

STATENUM	The STATENUM command sets the number of states used in Mueller matrix PDL measurements. Valid values are 4 and 6.
Interface:	GPIB and RS-232/USB
Syntax:	“STATENUM x”<CR> where x is the number of states
Returned Format:	None

STATENUM?	The STATENUM? command queries the number of states used in Mueller matrix PDL measurements.
Interface:	GPIB and RS-232/USB
Syntax:	“STATENUM?”<CR>
Returned Format:	<x><NL> where x is the number of states used for PDL measurements. Valid return values are 4 and 6.

RES	The RES command sets the resolution of the PDL and Power modes. Valid values are 2 and 3.
Interface:	GPIB and RS-232/USB
Syntax:	“RES x”<CR> where x is the resolution
Returned Format:	None

RES?	The RES? command queries the resolution of the meter
Interface:	GPIB and RS-232/USB
Syntax:	“RES?”<CR>
Returned Format:	<x><NL> where x is the resolution. Valid return values are 2 and 3.

T	The T command sets the meter into triggered or non-triggered(continuous) modes.
Interface:	GPIB and RS-232/USB
Syntax:	“T x”<CR> where x is a numeric value [0|1] OR a string [OFF|ON]
Returned Format:	None

T?	The T? command queries whether the meter is in triggered mode.
Interface:	GPIB and RS-232/USB
Syntax:	“T?”<CR>
Returned Format:	<x><NL> where x = 0 (triggered mode is OFF), x = 1 (triggered mode is ON).

TRIG	The TRIG command initiates a new measurement cycle. This command is primarily to be used in PDL triggered mode in conjunction with “PLD?” and “LAV?” commands.
Interface:	GPIB and RS-232/USB
Syntax:	“TRIG”<CR>
Returned Format:	None

ABS	The ABS command will switch the meter to absolute power mode.
Interface:	GPIB and RS-232/USB
Syntax:	“ABS”<CR>
Returned Format:	None

REL	The REL command will switch the meter to relative power mode.
Interface:	GPIB and RS-232/USB
Syntax:	“REL”<CR>
Returned Format:	None

BRM	The BRM command will switch the meter to BR mode.
Interface:	GPIB and RS-232/USB
Syntax:	“BRM”<CR>
Returned Format:	None

MODE?	The MODE? command queries the current operation mode, query return “ABS”, “REL”, “BRM” or “PDL” for the four different operating modes.
Interface:	GPIB and RS-232/USB
Syntax:	“MODE?”<CR>
Returned Format:	<Mode><NL> where <Mode> = “ABS”, “REL”, “BRM”, or “PDL”

SWL	The SWL command switches the meter to the next wavelength or to a specific wavelength using the wavelength (um) as reference.
Interface:	GPIB and RS-232/USB
Syntax:	“SWL”<CR> (switches to next wavelength) “SWL x.x”<CR> (where x.x = 0.8, 1.3, 1.4, 1.5 or 1.6). Example, “SWL 1.3” switches to 1310nm
Returned Format:	None

SWL?	Query returns the current wavelength number in “x.x” format, valid returns are 1.3 for 1310nm, 1.4 for 1480nm, 1.5 for 1550nm, 1.6 for 1625nm and 0.8 for 850nm.
Interface:	GPIB and RS-232/USB
Syntax:	“SWL?”<CR>
Returned Format:	<x.x><NL> where <x.x> = “0.8”, “1.3”, “1.4”, “1.5”, or “1.6”

SSC	The SSC command switches the meter to the next wavelength or to a specific wavelength using the position number/sequence as reference. The position of a laser in a particular meter will depend on the number of lasers in the meter.
Interface:	GPIB and RS-232/USB
Syntax:	“SSC”<CR> (switches to next wavelength) SSC x”<CR> (where x = 1, 2, 3, or 4). Example, “SSC 2” switches to the second wavelength (ie on a 2-wavelength PDL5 1310/1550, "SSC 2" would switch to 1550nm, however on a 1310/1480/1550/1625 "SSC 2" would switch to 1480nm)
Returned Format:	None

SSC?	Query returns the current wavelength position number in “x” format.
Interface:	GPIB and RS-232/USB
Syntax:	“SSC”<CR> (switches to next wavelength) “SSC?”<CR>
Returned Format:	<x ><NL> where < x> = “1”, “2”, “3”, or “4”

SCH	The SCH command can switch the meter to the next channel or to a specific channel
Interface:	GPIB and RS-232.
Syntax:	“SCH”<CR> (switches to next channel) “SCH xx”<CR> (where xx = 01, 02, 03,,,,23, 24). Example, “SCH 18” switches to channel 18
Returned Format:	None

SCH?	Query returns the current channel number in “xx” format, Valid returns are 01, 02, …12 (or 24, 36, 48 which is the total channel number)
Interface:	GPIB and RS-232.
Syntax:	“SCH?”<CR>
Returned Format:	<xx><NL> where <xx> = “01”, “02”, … “48”

DET	The DET command can switch the meter to the next detector or to a specific detector
Interface:	GPIB and RS-232
Syntax:	“DET”<CR> (switches to next detector) “DET xx”<CR> (where xx = 00, 02, 03,,,,4). Example, “DET 1” switches to detector 1
Returned Format:	None

DET?	Query returns the current detector number in “xx” format, Valid returns are 00, 01, 02…
Interface:	GPIB and RS-232
Syntax:	“DET?”<CR>
Returned Format:	<xx><NL> where <xx> = “00”, “01”, …

BRZS	The BRZS command will store BR_0. The meter needs to be in BR mode or dual display mode for the command to succeed.
Interface:	GPIB and RS-232/USB
Syntax:	“BRZS”<CR>
Returned Format:	None

BRZC	The BRZC command will clear BR_0. The meter needs to be in BR mode or dual display mode for the command to succeed.
Interface:	GPIB and RS-232/USB
Syntax:	“BRZC”<CR>
Returned Format:	None

DARK	The DARK command will store dark current. The meter needs to be in POWER mode for the command to succeed.
Interface:	GPIB and RS-232/USB
Syntax:	“DARK”<CR>
Returned Format:	None

TREF	The TREF command will take relative power reference. The meter needs to be in relative power mode for the command to succeed.
Interface:	GPIB and RS-232/USB
Syntax:	“TREF”<CR>
Returned Format:	None

TMF	The TMF command will initiate a measurement transmission in full display format addition with current wavelength.
Interface:	GPIB and RS-232/USB
Syntax:	"TMF"<CR>
Returned Format:	Full LCD display plus current wavelength in x.x format. Example: "BR=-60.2dB 1.3"

TDO	The TDO command will cause the meter to transmit the data only. If in BR mode, the data is the BR, in Power mode, the data is the IL (or absolute power), and in Dual Display mode, the data is both the BR and IL.
Interface:	GPIB and RS-232/USB
Syntax:	"TDO"<CR>
Returned Format:	"-xx.x" for BR mode, "-xx.xx" for power mode, " -xx.x / xx.xx " for PDL mode

LCL	The LCL command is used to return the remote control status to local front panel control. Same function as with the "Local" key on front panel.
Interface:	GPIB and RS-232/USB
Syntax:	"LCL"<CR>
Returned Format:	None